

Balance Training Reduces Falls Risk in Older Individuals With Type 2 Diabetes

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OBJECTIVE — This study assessed the effects of balance/strength training on falls risk and posture in older individuals with type 2 diabetes.

RESEARCH DESIGN AND METHODS — Sixteen individuals with type 2 diabetes and 21 age-matched control subjects (aged 50–75 years) participated. Postural stability and falls risk was assessed before and after a 6-week exercise program.

RESULTS — Diabetic individuals had significantly higher falls risk score compared with control subjects. The diabetic group also exhibited evidence of mild-to-moderate neuropathy, slower reaction times, and increased postural sway. Following exercise, the diabetic group showed significant improvements in leg strength, faster reaction times, decreased sway, and, consequently, reduced falls risk.

CONCLUSIONS — Older individuals with diabetes had impaired balance, slower reactions, and consequently a higher falls risk than age-matched control subjects. However, all these variables improved after resistance/balance training. Together these results demonstrate that structured exercise has wide-spread positive effects on physiological function for older individuals with type 2 diabetes.

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Older individuals with type 2 diabetes often exhibit greater impairments in posture and gait and are typically at increased risk of falling (1,2). This study was designed to assess whether type 2 diabetic individuals exhibited differences in balance, reaction time, and falls risk compared with control subjects and to examine the effects of training on these measures.

RESEARCH DESIGN AND METHODS

Sixteen type 2 diabetic individuals (62.3 ± 5.5 years; average diabetes duration 15.2 ± 2.4 years) and 21 age-matched control subjects (64.7 ± 7.1 year) participated. Exclusion criteria included cardiovascular disease, unstable proliferative retinopathy, end-stage renal disease, uncontrolled hypertension, and/or participation in balance/resistance

training during the previous year. All procedures complied with institutional review board guidelines.

Initial assessment included a complete history, physical examination, and full neurologic evaluation that included assessment for somatic/autonomic neuropathy (3). Warm-cold thermal perception, 128-Hz vibration perception, touch, pressure, and pricking pain perception were evaluated. An overall total neuropathy score was also calculated. The average A1C for the type 2 diabetic group was $7.5 \pm 0.3\%$. Following screening, a record of previous falls, balance, reaction time, and falls risk assessments were completed. Individuals then completed a 6-week, thrice-weekly exercise program followed by posttraining evaluations.

Each exercise session consisted of a balance/posture component (e.g., lower-

limb stretches and leg, abdominal, and lower-back exercises) and a resistance-/strength-training component (e.g., lower-/upper-limb exercises performed using strength-training machines). Participants performed 1–2 sets of 10–12 repetitions, with rests between exercises.

Falls risk

Risk of falling was determined using the long-form physiological profile assessment (PPA). This validated tool (4) assesses vision, sensation, proprioception, lower-limb strength, postural sway/coordination, and cognitive function.

Participants completed a simple reaction time (SRT) task where upper-limb (finger) and lower-limb (foot) responses were assessed. Individuals responded to a visual cue by depressing a timing switch. Fifteen trials were completed with each segment.

A repeated-measures, generalized linear model was used to assess for group and training effects. Significant effects were further examined using planned contrasts (one-way ANOVAs). Analyses were performed using SAS statistical software (SAS Institute) with $P < 0.05$.

RESULTS

Clinical assessment

Diabetic individuals exhibited significant differences in total neuropathy scores (left foot $F_{1,35} = 9.87$; right foot $F_{1,35} = 8.86$; all $P < 0.05$), BMI ($F_{1,35} = 22.50$; $P < 0.05$), and percent body fat ($F_{1,35} = 7.11$; $P < 0.05$). There were no significant group/exercise differences in blood pressure measurements for either sitting (pretraining: control subjects $128.2 \pm 3.4/73.4 \pm 2.3$ mmHg, type 2 diabetes $133.0 \pm 4.2/69.1 \pm 2.7$ mmHg; posttraining: control subjects $123.6 \pm 2.8/70.7 \pm 2.2$ mmHg, type 2 diabetes $130.0 \pm 4.6/67.4 \pm 3.2$ mmHg) or standing (pretraining control subjects $125.8 \pm 2.8/73.8 \pm 2.2$ mmHg, type 2 diabetes $133.4 \pm 4.1/72.14 \pm 3.3$ mmHg; posttraining control subjects $119.8 \pm 2.9/74.6 \pm 2.5$ mmHg, type 2 diabetes $127.7 \pm 6.0/68.8 \pm 3.2$ mmHg). No significant group/exercise differences were found for the following measures of auto-

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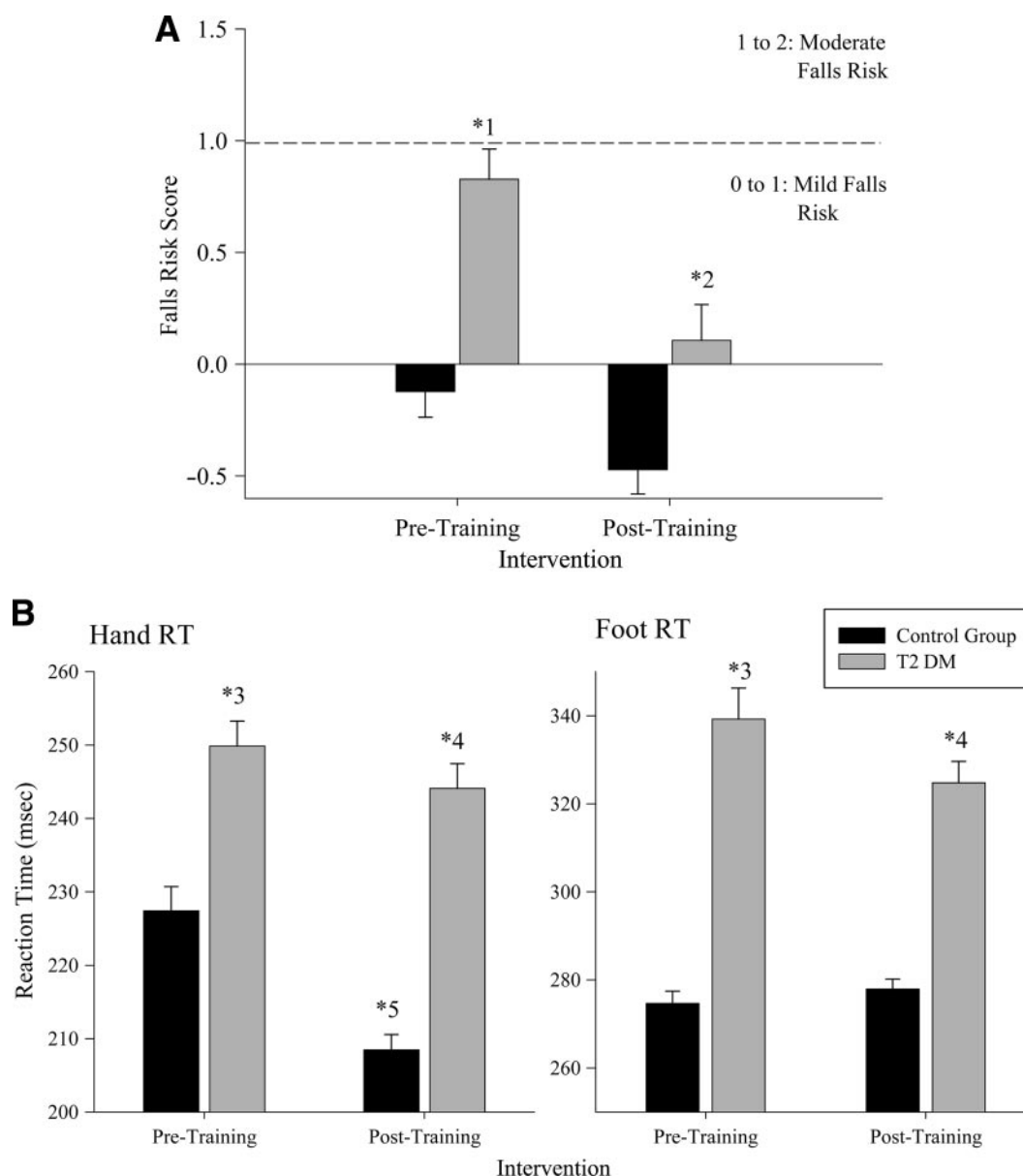


Figure 1—Changes in the falls risk (A) and average hand and foot simple reaction times (B) between control and type 2 diabetic groups. Mean values are shown for each group prior to and following the exercise intervention. Error bars represent 1 SE of the mean. For the falls risk, significant differences were observed between the groups prior to exercise (*1) and, for the type 2 diabetic group only, following training (*2). For the reaction time (RT) results, significant differences were observed in the hand and foot reaction time values between the groups prior to exercise (*3). Following training, the type 2 diabetes exhibited a significant reduction in both foot and hand reaction time values (*4). For the control subjects, only the hand reaction time values showed a decrease after training (*5).

nomic function: expiration-to-inspiration (E:I) ratio (control subjects 1.13 ± 0.02 ; type 2 diabetes 1.15 ± 0.02), Valsalva maneuver (control subjects 1.25 ± 0.03 ; type 2 diabetes 1.25 ± 0.07), and stand ratio (control subjects 1.36 ± 0.16 ; type 2 diabetes 1.48 ± 0.29).

Falls history

A significant group difference was found for the average number of falls ($F_{1,35} = 4.44$; $P < 0.05$), with type 2 diabetic subjects experiencing more falls over the past

year. No group difference in falls was observed posttraining.

Falls risk

As shown in Fig. 1, type 2 diabetic subjects had a significantly higher falls risk score compared with control subjects ($F_{1,35} = 20.24$; $P < 0.05$). Following training, both groups exhibited reduced falls risk, but this was only significant for type 2 diabetic individuals ($F_{1,35} = 33.03$; $P < 0.05$). While no age effects were observed, correlation analysis re-

vealed a significant falls risk–age relationship for the type 2 diabetic group ($r = 0.519$; $P < 0.05$).

Analysis of the individual PPA measures showed that type 2 diabetic individuals exhibited reduced proprioception ($F_{1,35} = 5.89$; $P < 0.05$), sensation ($F_{1,35} = 5.78$; $P < 0.05$), and ankle strength ($F_{1,35} = 4.17$; $P < 0.05$) compared with control subjects. Following training, a significant group-by-exercise effect was seen for proprioception ($F_{1,35} = 4.54$; $P < 0.05$), quadriceps ($F_{1,35} = 9.11$; $P < 0.05$), and ankle strength ($F_{1,35} = 4.17$; $P < 0.05$).

0.05), and hamstring strength ($F_{1,35} = 5.07$; $P < 0.05$). Planned contrasts revealed that both groups showed improvements in strength and proprioception postexercise.

Reaction time

There was a significant group difference for hand ($F_{1,35} = 7.22$; $P < 0.05$) and foot SRT ($F_{1,35} = 9.64$; $P < 0.05$), with the diabetic group being significantly slower (Fig. 1). Posttraining, a significant improvement in both SRT measures (hand $F_{1,35} = 11.87$; foot $F_{1,35} = 14.52$; all $P < 0.05$) was found. Planned contrasts revealed that both groups recorded faster hand SRT following exercise. However, only the type 2 diabetic group exhibited significantly faster foot SRT posttraining.

CONCLUSIONS— Normal aging is associated with slower cognitive processing (5), slower postural reactions (6), and decreased muscle strength (7), all of which are essential for optimal balance (8). The current study demonstrated that all older individuals showed a decline in SRT and strength, although the decrement was more pronounced for those with diabetes. The decline in function for older diabetic individuals was further compounded since they had a higher previous history of falls and all exhibited mild-to-moderate neuropathy, the latter being associated with increased falls risk (9). Consequently, the type 2 diabetic group was at greater falls risk, confirming the view that increasing age, previous falls history, increased postural sway, and presence of diabetes are major risk factors for falling (1,2,8,10–12).

Following training, the diabetic group exhibited a significant decline in falls risk, dropping from a mild-to-moderate to a low-to-mild risk of falling. This decline was reflected by improved proprioception and increased hamstring/quadriceps strength. While increasing physical activity can lead to enhanced joint proprioception, a learning effect cannot be ruled out as a contributing factor for the improved lower-limb proprioception. Both groups also demonstrated significant improvements in SRT. The ability to respond quickly to any external perturbation is essential for correcting oneself to avoid possible falls (4,6,11). Unfortunately, many older individuals

exhibit slower reaction times (5,11) and are at increased risk of falling since they respond slower under postural situations (6). The improved reaction time with exercise has obvious implications for individuals at high falls risk to correct themselves during balance-threatening situations. While hypoglycemia could be one reason for slower reaction times for the diabetic group (13), any decreased glucose levels would not explain the significantly improved SRTs seen postexercise. While increased strength correlates highly with improved balance and decreased falls risk (14,15), our results show that the benefits of exercise are not limited to muscle function. Rather, training resulted in improvements in a range of falls risk factors, impacting positively on sensory, motor, and cognitive processes.

Overall, this study demonstrated that older type 2 diabetic individuals are at increased falls risk. Following training, the type 2 diabetic group demonstrated improvements in balance, proprioception, lower-limb strength, reaction time, and, consequently, decreased risk of falling. The results support the practice of prescribing mild-to-moderate exercise to individuals with type 2 diabetes to alleviate falls risk.

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